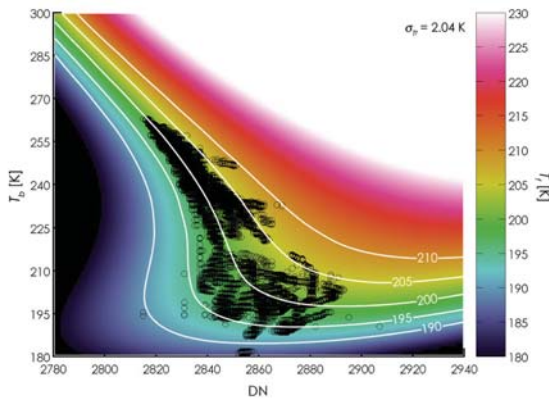


**Introduction:** The original calibration function of the  $R_H$  sensor on the Phoenix mission's Thermal and Electrical Conductivity Sensor (TECP), has been revised to correct the erroneously-published original calibration equation, to demonstrate the value of this unique data set, and to improve characterization of  $H_2O$  exchange between the martian regolith and atmosphere. TECP returned two data streams, the temperature of the electronics analog board ( $T_b$ ) and the digital 12-bit output of the  $R_H$  sensor ( $DN$ ), both of which are required to uniquely specify the  $H_2O$  abundance. Because the original flight instrument calibration was performed against a pair of hygrometers that measured frost point ( $T_f$ ), the revised calibration equation is also cast in terms of frost point.

The choice of functional form for the calibration function is minimally constrained. A series of profiles across the calibration data cloud at constant  $DN$  and  $T_b$  does not reveal any evidence of a complex functional form. Therefore, a series of polynomials in both  $DN$  and  $T_b$  was investigated, along with several non-linear functions of  $DN$  and  $T_b$ .

**Calibration:** Comparing the  $DN - T_b$  domain of the calibration data with that of the flight data (Figure 1), it can be seen that the high- $T_b$  (afternoon) and low- $T_b$  (overnight) extrema of the flight data are poorly constrained by the calibration data. In particular, because of the complexity of maintaining very low temperatures and high  $R_H$  in the chamber, no calibration data exists at  $T_b < 203K$ ; unfortunately, virtually all overnight data plots at the bottom of the data cloud, below 203 K.

In order to address the fact that the calibration data



**Figure 1.** The revised calibration (surface) and the calibration data. The  $DN-T_b$  domain of the flight data is indicated.

set does not reach temperatures below 203 K, while the sensor response over the course of the mission was smooth and continuous down to 181 K, we have opted to use flight data, acquired during periods when the base of the atmosphere is known to have been saturated.

The best fit to the calibration data was found with a 7-parameter linear equation of the form:

$$T_f = a_1 DN^2 + a_2 DN + a_3 DN T_b^{-1} + a_4 T_b^3 + a_5 T_b^2 + a_6 T_b + a_7 \quad [1]$$

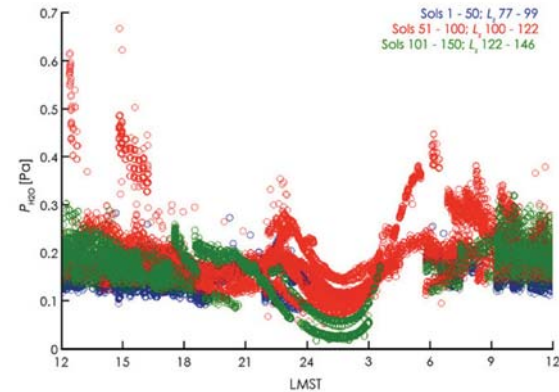
**Table 1.** Least Squares Fitted Parameters

	$a$	$\sigma_a$
$a_1$	$-1.724 \times 10^{-3}$	$\pm 1.014 \times 10^{-5}$
$a_2$	11.460	$\pm 0.055$
$a_3$	-294.484	$\pm 1.717$
$a_4$	$-2.218 \times 10^{-3}$	$\pm 1.504 \times 10^{-6}$
$a_5$	0.222	$\pm 1.456 \times 10^{-3}$
$a_6$	-83.956	$\pm 0.523$
$a_7$	-4648.92	$\pm 126.531$

The fitted values,  $a$ , are given in Table 1. For this data set,  $\sigma_T = 2.6$ .

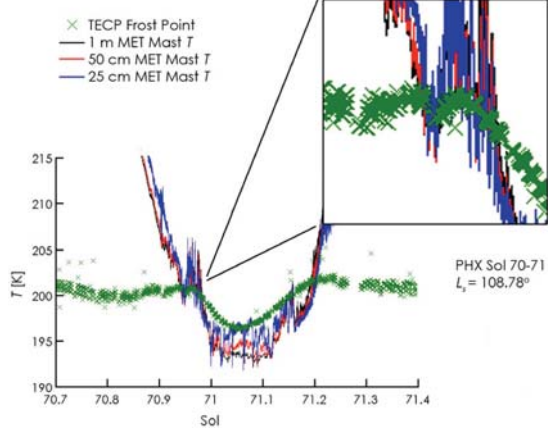
**Heading Styles:** The partial pressure of  $H_2O$  measured by the TECP over the course of the entire mission is given as a function of Local Mean Solar Time (LMST) in Figure 2. These numbers are lower than originally reported, but otherwise exhibit the same patterns.  $H_2O$  vapor varies strongly over daylight hours turbulence in the boundary layer shuttles parcels of air vertically. In the evening, the atmosphere stabilizes and atmospheric temperatures begin a smooth radiatively cooling period (Figure 3). Atmospheric  $H_2O$  decreases due to exchange with at least two identifiable reservoirs: ice and adsorbate.

The amount of atmospheric  $H_2O$  begins to decrease prior to atmospheric saturation, exhibiting a repeatable slope in  $P-T$  space. The enthalpy change associated



**Figure 2.** Partial pressure of  $H_2O$  as a function LMST for the entire mission.

with this exchange is  $\sim 3 \times 10^4$  [J/mole]. After about Sol 70, the atmosphere saturated each evening, and ground fogs were observed<sup>1</sup>. The slope of the  $\ln(P)$ - $T$  curve then transitions smoothly to that of ice condensation, with  $\Delta H = 5.1 \times 10^4$  [J/mole]. As the mission pro-



**Figure 3.** Sol 70 air temperatures from the MET mast, and  $T_f$  from TECP. Inset demonstrates TECP also records the onset of atmospheric saturation in the  $T_f$  data.

gressed from summer solstice to late summer, nighttime temperatures decreased, and the atmosphere saturated earlier in the evening.

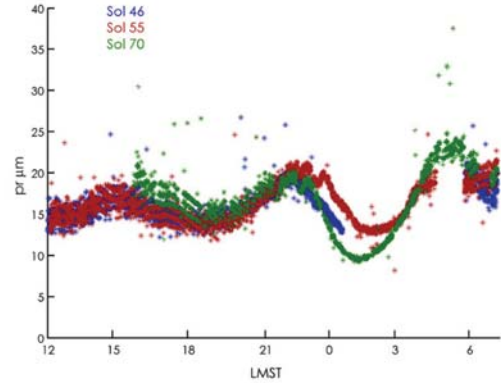
The average daytime  $[H_2O]$  varied relatively little from its average value of  $\sim 0.2$  Pa. This corresponds to somewhat less vapor than observed from orbit (Figure 4), which has raised issues about the validity of the data.

It is true that the TECP  $R_H$  sensor returned data over only about 5% of its available  $DN$  range, and therefore there is unavoidable error as a result of ADC process. This problem is particularly acute in the late afternoons when the electronics board temperatures were highest. Nonetheless, we have confidence in the  $H_2O$  vapor abundances derived here, in part because of the correspondence with the saturation detection in the MET temperature data.

In addition, the discrepancy between surface measurements of  $H_2O$  and orbital determinations (about 50%) was likewise reported by Viking<sup>2</sup>, but was then ascribed to overnight exchange. Here we find the discrepancy occurs over the daylight hours as well, which requires another explanation altogether.

#### References:

- [1] Whiteway *et al.*, *Science*, 2009



**Figure 4.** The column abundance of  $H_2O$  based on integrating the TECP measurements.